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ABSTRACT

This paper explores the impact of emerging information technology on employment opportunities for non-college-educated and minority individuals during 1986-99, examining whether shifts in employment toward information technology related to upward shifts in skills that led to reduced entry-level and total employment opportunities for noncollege-educated and minority workers. The paper categorizes out-of-school, noninstitutionalized people as: nonhigh school graduates; high school graduates; some college graduates, including people with two-year degrees; and greater than or equal to college graduates. Employment is classified into core technology occupations, other-technology occupations, and basic occupations. Core technology occupations grew substantially faster than other occupation groups. There was a general upgrading of skills within occupations across industries. Minorities, except Latinos, experienced increases in relative education and skills. Employment per capita for the noncollege-educated workers group increased. Less-educated workers improved their employment during the latter 1990s in the core technology occupation group. Skills did not upgrade for entry-level workers in the basic occupation group, and education levels among these workers declined. Noncollege-educated, entry-level workers saw strong employment growth in basic occupations and modest growth in other technology-related occupations. (SM)

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HAS THE RISE OF THE DIGITAL ECONOMY REDUCED EMPLOYMENT OPPORTUNITIES FOR LESS-EDUCATED ADULTS?

October 20, 2000

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Recently, there have been several studies and reports discussing the impact of information technology on the economy. Most of this work focuses on the effects of information technology on skill requirements throughout the economy and, in particular, the shortage of skilled workers in the information technology sector. Several of these reports also touch upon the impact of information technology on the employment prospects of non-college-educated workers and minorities.

While the new economy is creating jobs that never existed before, it is also transforming older, more traditional work. For instance, secretaries and administrative assistants in the past had to take dictation, type, and file. Now the same positions require an ability to work with computers and business productivity software, such as word processing, spreadsheets, and electronic databases. Inventory workers in factories are now called on to use computers to keep track of production supplies and to order replacements. One result of this economic transformation is a growing demand for a higher-skilled workforce. However, the demand for higher skills may pose an enormous challenge for low-skilled workers. Even in a growing economy, many jobs may be inaccessible for those with low levels of education and job skills. This would exacerbate the already-documented growth in income inequality.

This paper will explore the impact of emerging information technology on employment opportunities for non-college-educated and minority individuals. Specifically, the paper will examine whether the shift in employment toward information technology is related to an upward shift in skills that has led to a reduction in entry-level and total employment opportunities for non-college-educated and minority workers. There are two main indicators that support the assertion that the rise in the digital economy and the resulting economic transformation has reduced opportunities for less-educated workers:

1) If employment shifted toward technology-related and, particularly, computer-oriented occupations, it would suggest that information technology has had a significant impact on employment opportunities.

2) If skills have upgraded within occupations and industries, it would suggest skill-biased technology change, such as the widespread use of computers that would likely disadvantage less-educated workers and job seekers.

In order to assess these two indicators, the paper will address two questions:

1) Was there a relationship between the shift in employment toward technology-related occupations and skill upgrading (a shift upward in skills for jobs that had previously been performed with lower-skilled employees)?

2) Did skill upgrading reduce entry-level and total employment for non-college-educated and minority workers?

Methodology

The paper focuses on all out-of-school, non-institutionalized individuals 18 to 64 years old (adults) residing in the United States. Using education as a proxy for skills, the sample will be divided into four education/skill groups: non–high school graduates; high school graduates; some college graduates, including individuals with two-year degrees; and "greater than or equal to college" graduates. The sample will be analyzed over the period of 1986 to 1999. This 13-year period was selected because it represents the peak of the two most recent economic expansions.

Given the concerns cited in the literature on growing income inequality, focusing just on employment growth may overstate the potential contribution to economic opportunity of occupations dominated by part-time work. In order to minimize this effect, the paper will focus primarily on changes in full-time employment rather than on total employment.

The paper will also use a proxy for examining entry-level workers. Labor economists use a simple formula to determine labor market experience. The formula is based on age and education.[1] Using this formula, the paper considers workers employed two years or less as entry-level workers.

Finally, employment is classified into three occupation groups. The first group consists of *core technology occupations*, including computer scientists and engineers. This group represents the occupations most directly involved in advances in information technology and includes highly educated, highly skilled intellectual workers. The second group, *other-technology occupations*, includes computer programmers, computer operators, technicians, and communications workers. This group is strongly influenced by advances in technology. These workers are more moderately to highly skilled and educated. The third group, *basic occupations*, includes all other occupations not found in the core or other technology occupations. This group is least directly affected by advances in information technology. It includes managers, teachers, and professionals, but also some high- and low-wage service employees. (See Appendix A for a full description of the three occupation groups.)

There are several caveats. First, employment is an imperfect measure of changes in demand. Both the demand of employers for additional workers, and the supply of workers available, influence employment. This suggests that changes in employment must be interpreted carefully. Where possible, changes in supply should also be included in the analysis.

Second, education as a proxy for skills is somewhat limited. Labor market or on-the-job experience can be a substitute for education. Individuals may be trained in short-term certification or skill development programs that do not result in an education credential. So job skills could increase even when observed education levels do not. However, education is the most reliable observed measure of skills. In general, while education has its limitations, it has proven to be a fairly useful approximation of job skills.

Third, the entry-level measure is only a rough approximation of entry-level employment. It is possible for individuals with more than two years of work experience (as measured by our formula) to hold entry-level jobs. However, it would require extensive in-depth analysis of individual occupations to determine whether more experienced workers are holding entry-level positions or, for that matter, whether inexperienced workers are holding non–entry-level jobs.

Fourth, the occupation groups are very broad. While these groups provide a useful framework for analysis, they do not allow detailed examination of occupation changes. For example, the occupation groups do not allow a detailed exploration of whether education levels for computer programmers have changed. There is also a reasonable possibility that some readers will disagree with the grouping. The goal here is to define occupation groups that have some coherence and allow for a range of education levels.

Fifth, this paper is primarily descriptive. Because the paper is not using multivariate techniques, it will not be able to establish causal relationships. As such, the findings can only suggest relationships.

This paper is divided into three sections. The first section will detail the findings of the research based on the two central questions. A discussion of the implications of the research findings for workforce development policy and practice will then follow. A detailed discussion of statistics for each of the two findings is included after the highlights of the findings and their implications.

Findings: Question 1

Did a shift in employment toward technology-related occupations lead to skill upgrading?

- Consistent with several other studies, employment for adult workers appears to have shifted significantly to core technology occupations from 1986 to 1999. However, the shift seems to have accelerated from 1992 to 1999.
- The primary beneficiaries of the shift to core technology occupations appear to have been college graduates. However, during the mid- to late-1990s, non-college-educated workers actually improved their employment in core technology occupations.
- As a result, the education level of experienced workers across all occupations appears to have shifted upward. However, this was not the case for entry-level workers. From 1992 to 1999, education levels for entry-level workers appear to have declined. This decline in education, though, was primarily in basic (non-technology) occupations. The core technology and other technology-related occupations saw skill and education increases.
- The findings on skill upgrading are somewhat tentative. When education changes in the population are examined, it appears that the supply of non-college-educated workers declined by roughly the same amount as their loss of employment.

Findings: Question 2

Did a shift toward higher education and skill levels (skill upgrading) reduce the employment opportunities for non-college-educated workers?

- Despite what appears to be an increase in the demand for college-educated workers, the employment per capita ratio for non-college-educated workers increased from 1986 to 1999.
- Unlike the situation for experienced workers, the growth in employment for non-college-educated, entry-level workers seemed to favor non-college-educated

workers. However, when employment growth is controlled for occupation group, most of the increase in employment for non-college-educated workers occurred in the basic occupation group.

- Unfortunately, the only group of non-college-educated workers whose probability of full-time employment (the employment per capita ratio) declined was African Americans without a high school education.

What are the implications of these findings?

- **The skill upgrading that seems to have occurred since 1986 is likely to be a long-term trend.**

There is no clear indication in the data examined for this paper that this trend is likely to change—though there are signs that it may be slowing. This means that workforce development efforts for the economically disadvantaged will have to operate in the context of increasing demand for highly educated skilled workers. This raises real concerns about the rapid attachment employment strategy for non-college-educated workers. Rapid attachment strategies may improve initial employment for less-educated workers, but without interventions to improve skills, these workers may have limited opportunities for job ladder and wage progression.

Despite skill upgrading, employment did improve somewhat for less-educated workers during the latter half of the 1990s. In fact, employment per capita actually increased for non-college-educated workers from 1986 to 1999. (However, the probability of non-college-educated workers finding full-time employment is still considerably below that of college-educated workers.)

However, even though the full-time employment prospects of non-college-educated workers did not appear to be hurt by the upgrading of skills, less-educated workers might still face significant problems. For the most part, non-college-educated workers improved their employment per capita primarily because the number of such workers declined—not because their employment increased. This could certainly spell problems for less-educated workers if the economy begins to moderate its growth.

- **In the short-term, there may be real opportunities to improve the access of non-college-educated workers to employment in the information (core) technology sector.**

The problem, though, is that even after strong employment growth, employment in core technology represents a very modest share of all employment for less-educated workers. The vast majority of all employment for less-educated workers continues to be in the slow-growth, basic occupation group.

The findings in this paper suggest that if employment opportunities do exist in the core technology occupations, the focus should be primarily on improving the hard skills of less-educated incumbent workers, rather than targeting entry-level workers. Employment for entry-level workers in core technology declined dramatically for non-college-educated workers, while employment for more experienced, non-college-educated workers improved during the last half of the 1990s.

However, the best opportunity for technology-related employment for non-college-educated workers may not be in the core technology occupations, but rather in the other technology-related occupation group. This occupation group includes programmers, computer operators, and technicians. Employment growth for both entry-level and experienced workers in this group grew during the last half of the 1990s. Full-time employment is relatively high and so are average wages. This occupation group is also accessible to less-educated workers. It has both a larger absolute number and relative proportion of non–college graduates than core technology. In 1999, there were about 5.8 million non-college-educated workers in other technology-related occupations, compared with only about 330,000 such workers in core technology occupations.

How might these two implications affect workforce development?

Given the general upgrading of skills in the labor market, attention should be given in the workforce development field to efforts that increase the hard skills of both incumbent and entry-level less-educated workers. A focus on hard skills would tend to favor strategies that put more emphasis on training closely connected to employers. Indeed, with incumbent workers, it would be necessary to fully engage employers in the training process.

But while some would argue that these systems ought to be connected to the needs of specific employers, it might be more effective in the long run to tie these employer-based approaches to industries or economic sectors. Increasingly, economic development practitioners have begun to recognize that development programs that are designed to meet the needs of individual employers are often inefficient and difficult to justify in terms of public impact. The emergence of the industry cluster development approach by local economic development practitioners tends to reflect this new awareness.

Similarly, in the workforce development field, practitioners have begun to experiment with sector employment initiatives. These sector approaches focus on an entire industry (or cluster of occupations that cut across several industries). The sector approach allows for a more strategic approach to organizing training resources (both employers and training intermediaries) on behalf of the economically disadvantaged. Employers in the same industry tend to require similar soft and hard skills.

There are several examples of sector employment initiatives that have started to examine training issues for incumbent workers. The key question is whether the types of short-term training and skill development found in these sector employment initiatives can be applied to the information technology field. The data in this paper and other studies, as well as some anecdotal evidence, suggest that because of current labor shortages in technology occupations, employers are willing to hire non-college-graduates if they can demonstrate that they have a certain degree of technical skill.[1]

An effective sector approach would involve developing regional workforce development partnership with employers, both public and private trainers, and nonprofit training intermediaries. The shape of these partnerships would vary depending on the key characteristics existing in each locale. However, several general principles are included below:

- Each of these partnerships needs to have a strong labor market research capacity. Employment and labor market situations change so rapidly that an effective partnership needs the ability to carry out or have immediate access to research resources. For example, this research paper's analysis was painted in rather broad strokes. In order to develop and implement a development strategy, it is important to have more detailed information on changes at the labor market level.
- If the economically disadvantaged are going to be included, there must be a strong intermediary that sees its primary mission as connecting low-income workers to good jobs. Without such an intermediary, the needs of low-income people may not be well met. This intermediary may assume a variety of roles. It could be an advocate for the needs of low-income job seekers. It may provide recruitment and outreach, and intake and case management services. It may also provide some skill training.
- If they exist, partnerships should seek to involve both public (community colleges for instance) and private (proprietary institutions) as training providers. Because many of these providers have to compete in the marketplace, they often have stronger connections to employers and have the resources to be more responsive to the changing labor market needs. The new Workforce Investment Act (WIA) actually encourages clients to shop for the best service provider, whether public, private, or nonprofit.
- There must be an effort to organize employers across sectors or industries. This is probably best done through employer collaboration, either with an existing entity,

[1] A regional affiliate manager for RoadRunner, a broadband Internet provider, indicated in an informal interview that his company was more than willing to hire non–college graduates if they had some technology training or experience.

such as a chamber of commerce, or a new institution. Despite popular perception, employers—especially small employers—are often unorganized. Organizing around issues such as workforce development and training are relatively new activities for most employers.

Discussion: Question 1

Did a shift in employment toward technology-related occupations lead to skill upgrading?

The popular perception is that the digital economy has increased the demand for technology-related occupations. Employment in the core information technology occupations—computer science, computer engineering, systems analysis, and programming—has grown at a rapid pace over the last 15 years.[2] However, all occupations within this group did not grow at the same rate. Between 1983 and 1998, while computer systems analysts and scientists increased at a rate of 433 percent, employment for computer programmers grew at around 38 percent—only slightly greater than the national average. In fact, computer systems analysis and science occupations grew even faster from 1995 to 1998.[3] However, there are some discrepancies in measuring this growth based on which occupations are included in the group.[4]

In order to examine whether and how much employment has shifted to technology occupations, this paper divides occupations into three groups:

- basic, non-technology occupations;
- core technology occupations, which use occupation definitions of similar to those used by the Department of Labor or the Commerce Department (computer programmers are not included); and
- other technology-related occupations (includes computer programmers and operators, as well as technicians).[5]

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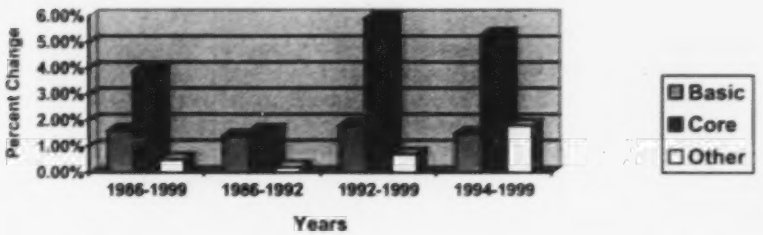
[2] Carol Ann Meares and John F. Sargent, Jr., *The Digital Workforce: Building Infotech Skills at the Speed of Innovation* (U.S. Department of Commerce–Technology Administration, Office of Technology Policy, June 1999), pp. 21–30.

[3] Meares and Sargent, pp. 21–22.

[4] Meares and Sargent, p. 24.

[5] See Appendix A: Methodology for definition of occupations used.

Figure 1. Percent Change in Annual Employment by Occupation Group



Employment growth has been very robust during the 1990s.

Total employment for 18- to 64-year-old adults increased from 104.0 million in 1986 to 127.0 million by 1999—a growth rate of 1.5 percent per year. However, employment in core technology grew more than twice as fast as employment in the other two occupation groups. Employment in core technology occupations grew from 2.4 million in 1986 to 4.0 million in 1999. (See figure 1.)

Because of this rapid growth, the percentage of total employment in core technology occupations has grown.

While the total number of jobs in core technology occupations is relatively modest, it has grown noticeably as a share of total employment. In 1986, 2.4 percent of total employment was in core technology occupations. By 1999, 3.6 percent of total employment was in core technology occupations. (See table 1.)

TABLE 1. PERCENT EMPLOYMENT BY OCCUPATION AS A SHARE OF TOTAL EMPLOYMENT

OCCUPATION	1986 SHARE	1986-1992	1992-1999	1994-1999
CORE	2.4%	2.3%	4.1%	3.6%
BASIC	81.7%	0.1%	0.1%	-0.1%
OTHER TECH	15.9%	-1.1%	-1.1%	0.1%

While changes in total employment provide an insight into the strength of the labor market, it can be somewhat misleading. Some occupations and economic sectors are dominated by part-time and even temporary employment. Success in the labor market for most workers is strongly tied to their capacity to work full-time. As such, full-time employment—along with wage rates—are a useful measure of job quality.

Full-time employment in core technology occupations grew twice as fast as employment in other occupations. In 1986, full-time employment in core technology occupations was 2.1 million; by 1999, employment was 3.5 million, an annual growth rate of 4 percent. Again, just as with total employment, while the share of full-time employment in core technology occupations was relatively modest (it was 2.8 percent in 1986 and 3.7 percent in 1999), it increased substantially over the period. (See table 2.)

When employment is controlled for full-time employment by occupation, core technology employment continues to show much stronger growth than other occupation groups.

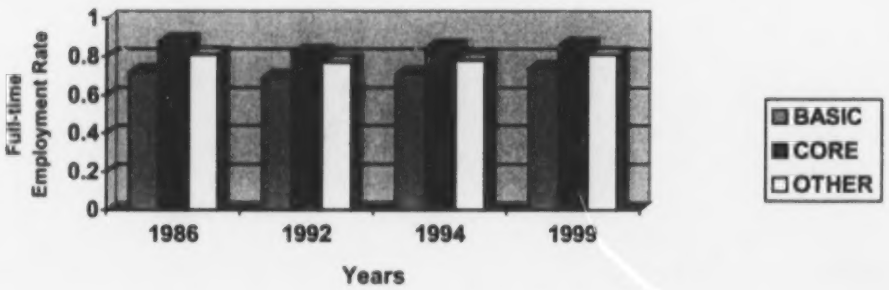
TABLE 2. COMPARISON OF ANNUALIZED PERCENT GROWTH IN FULL-TIME EMPLOYMENT BY OCCUPATION GROUP FOR ADULTS

OCCUPATIONS	1986-1999	1992-1999	1994-1999
BASIC	2.0	2.4	2.0
CORE TECHNOLOGY	4.0	5.9	5.0
OTHER TECHNOLOGY	0.5	1.2	2.0
ALL WORKERS	1.7	2.6	2.4

In 1986, 88 percent of all workers in core technology occupations worked full-time, compared with 72 percent and 81 percent in basic and other technology occupations respectively. There was a slight decline in the full-time employment rate within the core occupation group because part-time employment increased at a somewhat faster rate than full-time employment. Despite this, employment in the core technology group (and the other technology-related occupation group) provided the best opportunity for full-time work. (See figure 2.)

Workers in core technology occupations were more likely to be employed full-time when compared with workers in other occupation groups.

Figure 2. Full-time Employment Rate by Occupation by Year



Did employment shift to core technology occupations for entry-level workers?

While the data indicate that employment for 18- to 64-year-old adults increased fastest in core technology occupations, it is not clear that the same situation was true for entry-level employment. Table 3[6] compares annualized percentage growth in full-time employment by occupations.

Total entry-level employment grew from 7.0 million in 1992 to 8.3 million in 1999 across all occupation groups.[7] During this same period, entry-level employment in core technology occupations grew more than twice as fast as other occupations. From 1992 to 1999, employment in core occupations grew from 78,000 to 112,000. As a result, the share of all entry-level employment found in core technology occupations rose from 1.1 percent to 1.4 percent. (See table 3.)

Employment for entry-level workers also grew much faster for core technology occupations compared with the other two occupation groups.

[6] Because of data problems, the paper will only be able to make comparisons for entry-level workers from 1992 to 1999.

[7] Moreover, full-time, entry-level employment has also been growing as a percentage of total full-time employment in all three occupation groups. See table in Appendix B for details.

TABLE 3. COMPARISON OF ANNUALIZED PERCENT GROWTH IN FULL-TIME ENTRY-LEVEL EMPLOYMENT BY OCCUPATION GROUP FOR ADULTS			
OCCUPATIONS	**1992 EMPLOYMENT**	**1992-1999 Annual Growth**	**1994-1999 Annual Growth**
BASIC	5,931,608	2.5%	2.1%
CORE TECHNOLOGY	78,346	5.3%	9.5%
OTHER TECHNOLOGY	965,179	1.8%	3.0%
ALL WORKERS	6,975,133	2.5%	2.3%

A final point, another measure of both relative changes in demand and job quality, is changes in relative wages. If there is a growing wage premium, it suggests that the occupation with the favorable wage rate is facing a higher demand for appropriately skilled workers.

There does appear to be a wage premium for the higher-skilled workers in both the core technology and the other technology-related occupation groups. However, the differential between the wage groups seems to have remained roughly constant. This suggests that if relative demand for core technology workers was higher than in other occupations, it did not appear to have been translated into increases in wage premiums. (See figures b-1 and b-2 in Appendix B.)

Average wages did appear to be considerably higher in the core technology occupations than in either the basic or the other technology-related occupations[8] for both experienced and entry-level workers.

Did the rise in information technology employment lead to an increase in the demand for higher skills?

An important assertion about the rise of the digital economy is that it is increasing the demand for high-level skills and education. This process, often called skill upgrading, has the potential to severely reduce employment among low-skilled, non-college-educated workers and exacerbate existing income inequality. The issue, then, is whether the observed shift in employment to core technology has been accompanied by skill upgrading.

There has been a good deal of literature over the last 10 to 15 years on changing demands for skills. Much of that literature has been motivated by an interest in rising income

[8] Wages in the other technology-related occupations are also noticeably higher than average wages in the basic occupation group.

inequality. Starting in the 1980s, researchers began to notice that the gap between the top and bottom wage earners seemed to be growing. There was particular concern because much of this growing inequality seemed to be occurring during the economic expansion of the 1980s.[9] The major question was what explained the growth in equality. There were two major explanations. One was that increased trade and globalization opened the U.S. economy to competition from low-wage producers. This rise in competition led to employment loss and wage stagnation, especially for non-college-educated workers. However, there appears to be limited support for the globalization assertion.[10]

The second explanation was that transformations in the economy were forcing employers to demand higher skills from their workforce. As a result, there were increasing shortages of highly educated, highly skilled workers and an overabundance of less-educated, low-skilled workers. In such a situation, the employment and wages of low-skilled workers would decline, while the employment and wages of high-skilled workers would climb.

Several researchers concluded that a good deal of the inequality gap could be explained by the relative shift in demand from a low-skilled to high-skilled workforce.[11] However, in their survey article on inequality, Levy and Murnane suggest that if the group with falling wages is growing, then the problem is rooted in supply side changes.[12] In other words, the economy may not have undergone an increase in the demand for skills; rather, growing numbers of low-skilled workers have simply depressed wages. This would be the case when there are supply shocks, such as a large wave of low-skilled immigrants.[13]

While there is evidence that the observed rise in inequality was driven by rising demand from employers for higher-skilled workers, there is also support for several alternative explanations. First, medium-skilled sectors of the economy, such as basic manufacturing, grew

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[9] Susan N. Houseman, "Job Growth and the Quality of Jobs in the U.S. Economy," Upjohn Institute Staff Working Paper 95-39.

[10] George E. Johnson, "Changes in Earnings Inequality: The Role of Demand Shifts," *Journal of Economic Perspectives* 11(2) (spring 1997): 41–54.

[11] Chinui Juhn, "Wage Inequality and Demand for Skill: Evidence from Five Decades," *Industrial and Labor Relations Review* 52 (3) (April 1999): 424–43; Frank Levy and Richard Murnane, "U.S. Earnings Levels and Earnings Inequality: A Review of Recent Trends and Proposed Explanations," *The Journal of Economic Literature* 30 (September 1992): 1333–81.

[12] Levy and Murnane, 1992.

[13] By all accounts, this did seem to happen during the 1980s and 1990s. However, the evidence on the impact of immigration on the low-skilled, low-wage labor market is mixed. See, for example, Mary C. Waters and Karl Esbach, "Immigration and Ethnic and Racial Inequality in the United States," *Annual Review of Sociology* 21 (1995): 419–46.

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rapidly during the 1940s when wage inequality declined and shrank during the 1980s when income inequality rose.[14] Second, it also appears that there were demand shifts within industries, suggesting growth in skill-biased technology change. That is, changes in technology favored workers with higher skills.[15]

The long-term trend toward increasing demand for skills has also been identified by researchers who were not specifically concerned with income inequality. In an article that was primarily interested in the role work organization plays in the distribution of skills and training, Paul Osterman also found that skills were being upgraded within industries. Using an original survey of private-sector employers, Osterman found that new forms of work required more skill. As a result, there was a definite trend toward skill upgrading. However, the trend was more pronounced for technical/professional jobs than for blue-collar workers. Firms were looking for higher skill levels for technical and professional workers as opposed to behavioral traits, such as teamwork, for blue-collar hires.[16]

Other researchers have found that the emergence of the digital economy has been a major factor in the higher demand for skills in the labor market. Kenneth Button et al. found that there is a new demand for higher-skilled workers arising from the growth of information technology occupations throughout the economy. *The State of the Cities 2000*, a HUD report, came to a similar conclusion.[17]

The literature suggests strong support for the hypothesis of skill upgrading throughout the economy, especially during the 1980s. This paper examines this hypothesis in light of the growth in the digital economy during the 1990s.

One method of measuring skill shifts is to compare the change in the ratio of non-college-educated workers to college graduates.[18] Table 4 shows the ratio of non-college-educated to college-educated workers by occupation.[19]

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[14] Juhn, 1999.

[15] George E. Johnson came to a similar conclusion in his 1997 article cited above.

[16] Paul Osterman, "Skill, Training, and Work Organization in American Establishments," *Industrial Relations* 34 (2) (April 1995): 125–45.

[17] Kenneth Button, K. Cox, R. Stough, and S. Taylor, *The Long Term Educational Needs of a High Technology Society*, http://www.Workforce21.org/research_synthesis.htm (2000); U.S. Department of Housing and Urban Development, *The State of the Cities 2000*, pp. 32–44.

[18] Johnson (1997) uses a similar approach.

[19] This ratio takes the total number of individuals with no more than a high school education and divides them by the total number of individuals with at least some college education.

TABLE 4. THE ANNUALIZED PERCENT CHANGE IN THE RATIO OF FULL-TIME EMPLOYED NON-COLLEGE-EDUCATED TO COLLEGE-EDUCATED WORKERS BY OCCUPATION				
	1986 RATIO	1986-1999	1992-1999	1994-1999
BASIC				
NON–HIGH SCHOOL	0.63	-3.6	-1.5	-1.0
HIGH SCHOOL	1.69	-2.7	-2.1	-1.9
SOME COLLEGE	1.08	-3.4	-1.0	-1.4
NON-COLLEGE TO COLLEGE-EDUCATED	1.12	-1.4	-1.7	-1.0
CORE TECHNOLOGY				
NON–HIGH SCHOOL	0.01	-7.6	-6.6	0.6
HIGH SCHOOL	0.13	-2.9	-2.6	1.0
SOME COLLEGE	0.38	-6.1	1.0	0.0
NON-COLLEGE TO COLLEGE-EDUCATED	0.11	-2.0	-3.1	1.0
OTHER TECHNOLOGY				
NON–HIGH SCHOOL	0.63	-6.0	-5.8	-3.4
HIGH SCHOOL	2.42	-3.6	-4.4	-3.2
SOME COLLEGE	1.71	-4.0	-2.1	-2.5
NON-COLLEGE TO COLLEGE-EDUCATED	1.13	-1.8	-3.5	-1.9

Employment has shifted toward college graduates in all three occupation groups, across all three time periods.

This supports the skill upgrading assertion. However, the pace of skill upgrading in the 1990s may not have been any greater than skill upgrading in the 1980s. When non–high school graduates, high school graduates, and individuals with some college education are compared with college graduates, skill upgrading seems to be slightly slower in the 1990s compared with the 1980s. On the other hand, when non-college-educated (high school and non–high school graduates) are compared with college-educated workers (college graduates and individuals with some college), it appears that skills have upgraded faster in the 1990s than in the 1980s. That is, it appears that having some college education provides a relative advantage in the labor market. (See table 4.)

Skill upgrading seems to have slowed somewhat during the last half of the 1990s.

Skill upgrading was slower in the last half of the 1990s than in the late 1980s and early 1990s. Most interesting was the fact that the process seems to have reversed itself during this period for the core technology occupation group. This slowing of skill upgrading may indicate labor shortages. (Table 4 also presents some surprises.)

Falling employment for non-college-educated workers is also influenced by falling supply.

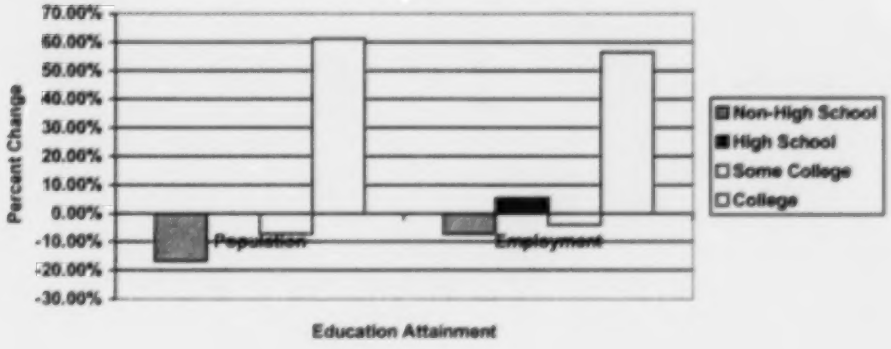
The declines in non-college-educated employment may represent falling demand, but they may also represent a declining supply. The number of non-college-educated workers relative to college-educated workers has declined by about 2 percent per year between 1986 and 1999 (roughly equal to the declines in employment for this group of workers). This suggests that a large portion of the decline in employment for non-college-educated workers may be the result of a decline in non-college-educated individuals in the population. (See table 5.)

TABLE 5. CHANGE IN NON-COLLEGE TO COLLEGE-EDUCATED POPULATION

	1986	1999	TOTAL CHANGE 1986-1999	ANNUAL CHANGE 1986-1999
NON–HIGH SCHOOL	1.10	0.57	-0.48	-0.05
HIGH SCHOOL	2.12	1.32	-0.38	-0.04
SOME COLLEGE	1.45	0.84	-0.42	-0.04
NON-COLLEGE EDUCATED TO COLLEGE-EDUCATED	1.31	1.03	-0.22	-0.02

Figure 3 provides further indication that declines in the population are a major explanation for falling employment for non-college-educated individuals. In fact, figure 3 shows that the population of non-college-educated workers fell faster than declines in their employment. Therefore, while there is evidence of skill upgrading, some of the shift in skills is the result of a declining non-college-educated population.

Figure 3. Change in Population and Full-time Employment by Education, 1986 - 1999



Did skills also upgrade for entry-level workers?

There is also a question about whether skills have upgraded for entry-level workers. Table 6 presents the ratio of non-college to college graduates by occupation group for four selected years covering the period from 1992 to 1999.

For workers with two years or less of labor market experience, the relative number of non–college graduates appears to have increased.

Since 1992, the ratio of non-college-educated to college-educated workers across all three occupation groups rose from 1.47 to 1.58 (roughly 1.5 non-college-educated workers to every 1 college-educated worker in 1992 to 1.6 non-college-educated workers to every 1 college-educated worker in 1999). However, because the vast majority of employment was in the basic occupation group, the decline in relative education for entry-level workers is primarily the result of a fall in education levels among entry-level workers employed in the basic occupation group. Relative education levels among entry-level core technology and other technology-related workers increased from 1992 to 1999.

During the period from 1992 to 1999, except for the core technology occupations, entry-level workers were much more likely than more experienced workers to be non–college graduates (see table 6). Of non–college graduates in 1992, there were 2.4 million in basic and 0.5 million in other technology-related occupations, compared with 2.1 million and 0.4 million college-educated workers, respectively, in these occupations. On the other hand, there was only a small portion of non–college graduates in entry-level core technology occupations. In 1992, there were 4,000 non–college graduates versus 71,000 college-educated workers.

The findings suggest that relative education among entry-level workers declined while it increased for more experienced workers. The greater demand for non-college-educated, entry-level workers in the non–core technology occupations again may be the result of labor shortages. That is, while there was skill upgrading among more experienced workers, it did not appear to be occurring among entry-level workers because entry-level college-educated workers might have been in short supply.

TABLE 6. THE ANNUAL RATIO OF ENTRY-LEVEL, FULL-TIME EMPLOYED NON-COLLEGE-EDUCATED TO COLLEGE-EDUCATED WORKERS BY OCCUPATION BY SELECTED YEARS

	1992	1994	1996	1999
BASIC				
NON–HIGH SCHOOL	1.54	1.45	1.76	2.11
HIGH SCHOOL	4.52	3.97	4.57	5.01
SOME COLLEGE	2.94	2.94	3.23	3.20
NON-COLLEGE TO COLLEGE-EDUCATED	1.54	1.38	1.50	1.70
CORE TECHNOLOGY				
NON-HIGH SCHOOL	0.02	0.00	0.00	0.01
HIGH SCHOOL	0.07	0.09	0.05	0.06
SOME COLLEGE	0.40	0.29	0.38	0.54
NON-COLLEGE TO COLLEGE-EDUCATED	0.07	0.07	0.03	0.04

TABLE 6. THE ANNUAL RATIO OF ENTRY-LEVEL, FULL-TIME EMPLOYED NON-COLLEGE-EDUCATED TO COLLEGE-EDUCATED WORKERS BY OCCUPATION BY SELECTED YEARS				
	1992	1994	1996	1999
OTHER TECHNOLOGY				
NON–HIGH SCHOOL	1.03	0.76	0.78	1.14
HIGH SCHOOL	4.42	3.53	3.73	4.01
SOME COLLEGE	3.17	2.57	2.83	3.16
NON-COLLEGE TO COLLEGE-EDUCATED	1.31	1.20	1.18	1.24
All WORKERS				
NON–HIGH SCHOOL	1.37	1.27	1.48	1.80
HIGH SCHOOL	4.19	3.67	4.09	4.47
SOME COLLEGE	2.79	2.72	2.95	2.98
NON-COLLEGE TO COLLEGE-EDUCATED	1.47	1.33	1.41	1.58

SUMMARY

The results presented so far provide support for the assertion that employment—both full-time and part-time—grew fastest in the core technology occupations. This pattern of growth seemed to hold for both entry-level and more experienced workers.

However, the findings about the existence of skill upgrading are more ambiguous. Employment growth in all three occupation groups from 1986 to 1999 appears to have disproportionately benefited college-educated workers, especially in the core technology occupations. The result was that employment for experienced non-college-educated workers relative to college-educated workers declined between 1986 and 1999.

This shift in employment from non-college-educated to college-educated workers could be interpreted as an indication of skill upgrading on the demand side. On the other hand, there has been a corresponding fall in the supply of non-college-educated workers. This fall indicates

that interpreting employment figures must be done carefully. The decline in the proportion of non-college-educated workers may actually be a supply effect rather than an increase in the demand for higher-skilled workers. The most likely explanation is that skills have upgraded but have been moderated somewhat by supply changes.

Examining entry-level workers suggests that skills may not have shifted upward for these workers. In fact, employment growth for entry-level workers seems to have favored non-college-educated individuals. This could be the result of increased employment demand leading to labor shortages.

Another indication of skill upgrading would be changes in relative wages favoring college-educated workers. While this paper did not directly explore changes in relative wages by education, there have been several empirical studies that have used this method. During the 1980s and early 1990s, relative wages shifted in favor of college-educated workers. That is, there was a definite wage premium for education.[20] This indicates that the demand for higher-educated workers relative to non-college-educated workers increased.

Taken as a whole, the evidence seems to support some degree of skill upgrading (i.e., a higher demand for more-educated workers relative to less-educated workers). Given this tentative conclusion, an important question is, what impact did the parallel shift in employment toward core technology occupations, and the upgrading of skills, have on the employment opportunities for less-educated workers?

Discussion: Question 2

Did a shift toward higher education and skill levels (skill upgrading) reduce the employment opportunities for non-college-educated workers?

The evidence presented above suggests at least some moderate support for the hypothesis of skill upgrading across all occupations for experienced workers. Across all occupations, employment shifted upward toward college-educated workers. As a result, the proportion of non-college-educated individuals employed full-time fell substantially within all three occupation groups. This is a strong indication that there has been skill upgrading within all three occupation groups. (At the same time, this conclusion must be balanced against the fact that the supply of non–college graduates also declined.) That is, employers are demanding higher skills and education than they did in the past for the same occupations. However, there appears to be little evidence of skill upgrading among entry-level workers. The question is

[20] George E. Johnson (1997); Chinhui Juhn, Kevin M. Murphy, and Brooks Pierce, "Wage Inequality and the Rise in Returns to Skill," *Journal of Political Economy* 101 (June 1993): 410–42.

whether the existing evidence of skill upgrading corresponds to declines in the employment opportunities available to non-college-educated workers.

Non–college graduates had either falling or stagnant employment growth, while college graduates benefited from a substantial increase in employment.

In all three occupation groups, non–high school graduates suffered a decline in full-time employment between 1986 and 1999. Employment for non–high school graduates declined from 10.3 million in 1986 to 9.5 million in 1999. However, employment for high school graduates actually increased from 29.4 million in 1986 to 31.0 million in 1999. This increase happened in the core technology and basic occupation groups (employment for high school graduates declined slightly in the other technology-related group).

However, from 1994 to 1999, both non–high school and high school–educated workers experienced positive employment growth in all three occupation groups. Surprisingly, the occupation group with the strongest full-time employment growth for non–college graduates during the mid- to late-1990s was the core technology group (see table 7). In fact, from 1994 on, the number of non–college graduates in the core technology occupations grew as fast or faster than the number of college graduates.

When employment is controlled for both occupation and education from 1986 to 1999, college graduates in all three occupation groups experienced the greatest employment growth; the fastest growth occurred in core technology. Employment for college-educated workers grew from 17.7 million to 27.7 million between 1986 and 1999. (See table 7.)

TABLE 7. ANNUALIZED PERCENT GROWTH IN FULL-TIME EMPLOYMENT BY EDUCATION AND OCCUPATION

OCCUPATION GROUP	1986-1999	1992-1999	1994-1999
BASIC			
LESS THAN HS	-0.2	2.1	2.5
HIGH SCHOOL	0.7	1.5	1.4
SOME COLLEGE	0.0	3.0	1.7
COLLEGE GRADS	3.5	3.7	3.4
TOTAL	1.2	2.5	2.1
CORE TECHNOLOGY			
LESS THAN HS	-3.4	-0.3	6.3
HIGH SCHOOL	1.5	3.8	6.8
SOME COLLEGE	-1.7	7.9	5.7
COLLEGE GRADS	4.6	6.8	5.7

TABLE 7. ANNUALIZED PERCENT GROWTH IN FULL-TIME EMPLOYMENT BY EDUCATION AND OCCUPATION			
OCCUPATION GROUP	**1986-1999**	**1992-1999**	**1994-1999**
TOTAL	3.1	6.6	5.9
OTHER TECHNOLOGY			
LESS THAN HS	-3.4	-2.1	0.8
HIGH SCHOOL	-1.0	-0.6	1.2
SOME COLLEGE	-1.4	1.6	1.9
COLLEGE GRADS	2.7	3.9	4.4
TOTAL	-0.6	1.0	2.1

While table 7 provides an assessment of absolute employment growth, employment opportunity is driven by two factors: the demand by employers for new workers and the supply of these workers. If, for example, the supply of non-college-educated workers declines faster than their employment, then employment opportunities may actually rise. On the other hand, if supply is growing faster than employment, then employment opportunity may decline even in the face of rising employment.

Employment per capita between 1986 and 1999 for non–high school and high school graduates and individuals with some college education increased.

Table 8 analyzes employment opportunities by calculating changes in the employment per capita ratio by education. If skill upgrading has hurt non-college-educated workers, then their employment per capita ratios should decline. This table presents the proportion of employment within occupations to total employment by education. (See table 8.)

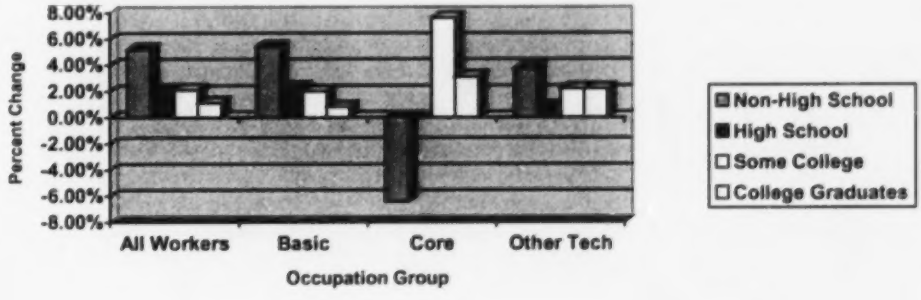
The increase in employment per capita seems to be primarily because of supply changes. Non–high school graduates' full-time employment fell by 16.7 percent while employment fell by only 7.1 percent. Employment for high school graduates rose by 5.5 percent, while population remained roughly stable. The number of individuals with some college education, including those with two-year degrees, fell by 7.1 percent, but employment declined by only 4.1 percent. On the other hand, despite strong employment growth, full-time employment per capita for college graduates fell slightly. While employment for college graduates rose by 56.4 percent, the number of college graduates climbed by 61.3 percent.[21]

[21] Calculations not shown in paper. However, figure 5 compare relative growth of highly educated to less educated in the population. Figure 5 indicates that college grads were growing much faster than less educated individuals.

TABLE 8. FULL-TIME EMPLOYMENT PER CAPITA RATIO BY EDUCATION FOR ADULTS			
EDUCATION	**1986**	**1999**	**1986 – 1999 GROWTH**
NON–HIGH SCHOOL	0.37	0.41	0.8%
HIGH SCHOOL	0.54	0.57	0.4%
SOME COLLEGE	0.52	0.54	0.2%
COLLEGE GRADUATES	0.69	0.67	-0.2%
ALL WORKERS	0.53	0.56	0.5%

These data suggest that the decline in full-time employment for non–college graduates was not entirely the result of falling demand. Indeed, it appears that the relative demand for these workers may have actually increased somewhat during the period between 1986 and 1999. So the possible skill upgrading that accompanied the rapid growth of information technology (core technology) employment did not appear to harm non–college graduates. Even non–high school graduates saw their full-time employment per capita improve. On the other hand, college graduates found their employment per capita declined slightly even though their employment increased considerably faster than the average, primarily because of the rapid increase in the relative supply of college graduates.

Figure 4. Annual Full-time Employment Growth by Education and Occupation for Entry-Level Workers, 1992 -1999



Absolute and relative employment for non-college-educated, entry-level workers also increased during the 1990s.

Figure 4 presents annual full-time employment growth by occupation and education for entry-level workers. Surprisingly, for all entry-level workers, non–high school graduates and high school graduates experienced the largest percentage of growth in full-time employment. However, when full-time growth is controlled for occupation, entry-level, non-college-educated workers did well in basic occupations and modestly well in other technology-related occupations, but very poorly in core technology occupations. Indeed, it appears that entry-level, non-college-educated workers in the core technology fields saw their opportunities decline dramatically, while college-educated workers in the same occupation group benefited from robust employment growth.

The findings here suggest that while there appear to be some opportunities for experienced, non-college-educated workers in the core technology occupation group, there are few if any opportunities for entry-level workers without a college education. Interestingly, the largest growth in employment in the core technology sector for entry-level workers was for individuals with only some college education. Employment for these workers climbed from about 20,000 in 1992 to about 34,000 in 1999 (college graduates still remained by far the largest group of entry-level workers in core technology).

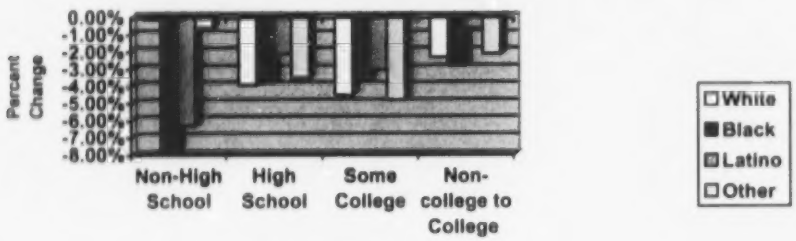
However, the other technology group does appear to provide some modest opportunities for entry-level, non-college-educated workers. In 1992, there were approximately 500,000 workers in the other technology area with no more than a high school education; by 1999, there were approximately 550,000 such workers. This sector also had fairly strong growth in employment for entry-level workers with some college education—employment rose from 291,000 in 1992 to 398,000 in 1998. The results here suggest that while entry-level, non-college-educated workers did not lose employment opportunities, they did not improve their relative position in technology fields.

Figure 4 shows that while there were modest opportunities for entry-level, non-college-educated workers in the other technology occupation groups, the largest absolute number of jobs remained in the basic occupation area. The number of entry-level workers with no more than a high school education rose from 3.3 million to 4.2 million between 1992 and 1999. Entry-level workers with some college education increased from 1.7 million in 1992 to 1.9 million by 1999. So overall, while skill upgrading may have reduced opportunities for entry-level, non-college-educated workers in core technology occupations, there were still a large number of full-time employment opportunities for these workers in other occupations.

Does race matter?

Given the historical problems of racial inequality in the labor market[22] and the disproportionate number of non-college-educated minorities, an upward shift in skills might have a particularly deleterious impact on employment opportunities for racial and ethnic minorities. If minorities do not improve their education levels as quickly as whites, their employment will most likely decline. Figure 5 shows the change in education relative to college graduates controlled for race and ethnicity, and tables 9 and 10 present the growth in full-time employment and the full-time employment per capita by race and ethnicity. While employment growth figures suggest that minority workers did fairly well during this period, it is still possible that skill upgrading reduced the probability of employment for racial minorities.

Figure 5. Percent Change in the ratio of Non-college Graduates to College Graduates by Race from 1986-1999



While whites and Asians and Pacific Islanders (others) had the highest absolute skill levels (as measured by education), figure 5 indicates that African Americans actually improved their skills at a faster pace.[23] On the other hand, Latinos tended to have the slowest improvement in skills. This

Except for Latinos, minorities upgraded their skills at a faster rate than whites.

[22] Shelly Lundberg and Richard Startz, "On the Persistence of Racial Inequality," *Journal of Labor Economics* 16 (2) (1998): 292–323; Steven Shulman, "Racial Inequality and White Employment: An Interpretation and Test of the Bargaining Power Hypothesis," *Review of Black Political Economy* 18 (Winter 1990): 5–20.

[23] Figure 5 measures the ratio of non-college educated to college educated. If the number of non-college grads declines while the number of college grads increases the change in the ratio would be negative. The larger the negative change the faster the relative increase in group education levels.

increase in skills for minorities should have translated into greater full-time employment opportunities.

Table 9 compares the growth in full-time employment by occupation and race. After controlling for occupation, minorities had faster growth in full-time employment than whites in all three occupation groups—including the core technology group. This seems generally consistent with minorities' improvement in education. However, Latinos had the greatest increase in employment despite having the smallest improvement in education. African Americans, on the other hand, had the largest increase in education but, among minorities, the smallest increase in full-time employment. These findings suggest that while improvements in education do help to explain some of the differences in employment growth, other factors may be critical in understanding racial and ethnic differences in employment.

For minorities, there was only a modest relationship between improved education and employment growth.

TABLE 9. ANNUALIZED PERCENT CHANGE IN FULL-TIME EMPLOYMENT BY RACE AND OCCUPATION

RACE AND OCCUPATION GROUP	1986-1999	1992-1999	1994-1999
BASIC			
WHITES	0.3%	1.3%	1.0%
AFRICAN AMERICANS	2.2%	4.0%	3.5%
LATINOS	5.4%	8.4%	8.2%
OTHER*	4.9%	6.5%	3.7%
ALL	1.2%	2.5%	2.2%
CORE TECHNOLOGY			
WHITES	2.4%	5.6%	4.2%
AFRICAN AMERICANS	4.7%	9.0%	12.1%
LATINOS	5.6%	8.9%	8.6%
OTHER*	8.5%	13.2%	17.0%
ALL	3.1%	6.6%	5.8%
OTHER TECHNOLOGY			
WHITES	-1.1%	0.1%	1.5%
AFRICAN AMERICANS	1.1%	2.7%	3.6%

TABLE 9. ANNUALIZED PERCENT CHANGE IN FULL-TIME EMPLOYMENT BY RACE AND OCCUPATION			
RACE AND OCCUPATION GROUP	**1986-1999**	**1992-1999**	**1994-1999**
LATINOS	1.6%	4.1%	4.6%
OTHER*	3.5%	5.2%	6.1%
ALL	-0.5%	0.9%	2.1%
ALL WORKERS			
WHITES	0.2%	1.3%	1.2%
AFRICAN AMERICANS	2.0%	3.9%	3.7%
LATINOS	4.9%	7.9%	7.8%
OTHER*	4.9%	6.8%	4.9%
ALL	0.9%	2.4%	2.3%
* Other = primarily Asian and Pacific Islanders			

The findings presented in table 9 suggest that despite general skill upgrading in the labor market, minorities managed to improve their employment. However, as discussed earlier, both demand and supply influence employment opportunity.

In general, while whites had higher employment per capita than minorities, minorities tended to have larger growth in employment ratios.

Table 10 presents the full-time employment per capita ratios by race. In most instances, non-college-educated minorities did as well as or better than similar whites. While less-educated minorities had lower employment per capita than comparable whites, they had, for the most part, stronger growth. The only exception was African Americans without a high school education. In general, table 10 suggests that despite skill upgrading, less-educated workers across all four racial/ethnic groups managed, for the most part, to hold their own.

TABLE 10. FULL-TIME EMPLOYMENT PER CAPITA BY RACE AND EDUCATION			
RACE/EDUCATION	**1986**	**1999**	**1986-1999**
WHITE			
NON–HIGH SCHOOL	0.38	0.39	3.8%
HIGH SCHOOL	0.54	0.57	5.4%
SOME COLLEGE	0.53	0.54	2.3%

TABLE 10. FULL-TIME EMPLOYMENT PER CAPITA BY RACE AND EDUCATION			
RACE/EDUCATION	**1986**	**1999**	**1986-1999**
COLLEGE GRADUATES	0.69	0.67	-3.1%
BLACK			
NON–HIGH SCHOOL	0.30	0.29	-4.4%
HIGH SCHOOL	0.51	0.55	7.7%
SOME COLLEGE	0.50	0.55	9.7%
COLLEGE GRADUATES	0.72	0.72	-0.4%
LATINOS			
NON–HIGH SCHOOL	0.41	0.49	21.1%
HIGH SCHOOL	0.54	0.58	6.9%
SOME COLLEGE	0.52	0.55	7.0%
COLLEGE GRADUATES	0.70	0.67	-4.0%
OTHERS			
NON–HIGH SCHOOL	0.33	0.41	22.8%
HIGH SCHOOL	0.52	0.53	1.8%
SOME COLLEGE	0.43	0.46	7.1%
COLLEGE GRADUATES	0.69	0.65	-5.2%

SUMMARY

The findings presented in this section indicate that non-college-educated workers and minority workers have managed to maintain or improve their status in the labor market despite evidence of skill upgrading (see table 7). In fact, non-college-educated workers actually had an increase in full-time employment per capita. At the same time, college graduates actually experienced a slight decline in their employment per capita ratio. The only exception to the good news for non-college-educated workers was that African Americans without a high school education were the only group to see their probability of working full-time decline.

Given the upgrading of skills, it seems counterintuitive that employment per capita for non-college-educated workers increased. However, table 10 and figure 3 provide some explanation. The employment per capita ratio is based on changes in employment and changes in population. The ratio will rise if employment goes up or if the population declines.

In this case, figure 3 indicates that employment decreased less than or increased more than the population of non–college graduates. The outcome was that employment per capita rose for non–college graduates. On the other hand, while employment for college graduates increased substantially (see table 7), the population of college graduates increased even faster (see figure 3). As a result, employment per capita for college-educated adults declined. Therefore, while college graduates had substantially higher employment per capita than non–college graduates, the rate of growth in employment per capita favored the non-college-educated.

There is some indication that the core technology occupation group may be experiencing spot labor shortages. While core technology occupations had the highest level of education (see table 6), there was a considerable increase in full-time employment for non-college-educated workers (see tables 7 and 8). This suggests that while the labor market was demanding a higher level of skills, employers in core technology occupations had difficulty finding workers and therefore might have been willing to hire less-educated workers.

However, the proportion of non–college graduates in core technology occupations is very small compared with the other two occupation groups. This suggests that while opportunities are growing, they represent only a fraction of the labor market for less-educated workers. The lion's share of full-time employment for less-educated workers continues to be in the relatively slow growth, basic occupation group, followed by the other technology group.

Finally, among entry-level workers, the non-college-educated actually had the greatest employment growth. This may be another indication that labor shortages during the 1990s economic expansion were most acute for entry-level workers.

CONCLUSION

The increase in the demand for higher-skilled workers growing out of the rise of the digital economy within all occupations and economic sectors has significant implications for workforce development efforts aimed at the economically disadvantaged. The current trend in workforce development for the disadvantaged is to focus first on rapid attachment to the labor market.[24] Rapid attachment assumes that there are sufficient low-skilled, low-wage employment

[24] This approach is popularly known as "work first." It is premised on the belief that the best approach to training is a job.

opportunities to take care of the needs of low-skilled workers. Further rapid attachment also assumes that these low-skilled jobs will provide the foundation for career ladders. However, if employers are demanding higher skills across all occupations, then low-wage, low-skilled jobs may not lead to advancement. Moreover, if the demand for skills is rising, the number of low-skilled, low-wage employment opportunities may also be declining in all industries and occupations, even in the midst of economic expansion.

This paper attempted to determine indirectly whether the growing information technology sector has reduced employment opportunities for non-college-educated workers. The focus was on changes in full-time employment from 1986 to 1999 for 18 to 64-year-old adults. The findings indicate that the generally high-skilled core technology occupations grew substantially faster than those in the other occupation groups. Moreover, there has been a general upgrading of skills within occupations across all industries in the U.S. economy. (Racial and ethnic minorities, except for Latinos, also experienced an increase in relative education and skills.) These developments would normally spell bad news for non-college-educated workers.

However, despite these developments, non-college-educated workers did surprisingly well. Employment per capita for non-college-educated workers increased from 1986 to 1999. Most unexpected was the fact that less-educated workers improved their employment during the latter half of the 1990s in the core technology occupation group—the high-skill, high-education group. The good news also seemed to extend to racial and ethnic minorities. While there continues to be a sizable gap in employment between whites and minorities, for the most part, non-college-educated minority workers had stronger full-time employment growth than comparable whites.

The situation for entry-level workers was more complex. Entry-level employment in core technology (information technology) occupations also grew well above the average. However, the question of skill upgrading was a little more difficult to decipher. Skills did not upgrade for entry-level workers in the basic occupation group. Indeed, education levels among entry-level workers actually declined. On the other hand, education levels did increase in the core technology and other technology-related occupation groups.

Employment growth for non-college-educated, entry-level workers was also not entirely straightforward. Non-college-educated workers saw strong employment growth in basic occupations and modest growth in other technology-related occupations. However, entry-level employment for non-college-educated workers in core technology occupations was negative.

APPENDIX A: METHODOLOGY

This paper uses descriptive statistical analysis to examine changes in the demand for skills during the period covering 1986 to 1999. This represents the peaks of two of the United States' most robust economic expansions—the 1980s and the 1990s. This period allows an examination of peak-to-peak changes as well as trough-to-peak analysis.

The sample is composed of individual observations drawn from a data set compiled by researchers at the Urban Institute's Program on Regional Economic Opportunity. The data set itself is derived from the Outgoing Rotation of the Current Population Survey from 1986 to 1999. The sample represents all working[25] and non-working, out-of-school, non-institutionalized individuals 18 to 64 years old. Race is used to stratify the sample.

The paper uses education as a proxy for skill. Obviously, education may not account for all relevant labor market–related skills. However, most of the research on skill shifts use education as a reasonable indicator. The paper uses four education categories: less than high school education, high school only, some college, and four-year college education or greater. The paper also combines high school and less than high school into a category called non-college-educated and compares it with college-educated individuals (i.e., individuals with greater than a high school education).

The paper uses three occupation categories to compare changes in employment (see below for description of occupation groups). Changes in employment are used as an approximation for changes in demand. The expectation is that the long period over which employment changes will be studied will provide a reasonable measure of demand shifts.

Supply changes are examined by studying variations in the population. So for example, if employment for high school dropouts declines, but the population of high school dropouts stays the same, then changes in demand probably account for much of the employment change. On the other hand, if the number of dropouts rises while employment remains roughly the same, the changes are driven primarily by the growth in supply.[26]

The paper also attempts to examine the changes in employment for entry-level workers. Identifying individuals with no more than two years of labor marker experience approximates

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[25] In this version of the paper, total employment was used. In the final version, the paper will also focus on full-time employment.

[26] In the final version of this paper, changes in wages will also be examined as another measure of demand shifts. The final version will also review changes in entry-level jobs separately. Entry-level jobs are defined as those held by individuals with no more than two years of labor market experience. (Labor market experience = Age - years of education - 6.)

entry-level workers. Labor market experience is calculated by subtracting years of education from age and then subtracting 6. Because of data problems, the findings for entry-level workers only cover the period from 1992 to 1999. Entry-level workers are not synonymous with entry-level jobs. Entry-level workers are individuals with limited labor market experience. The assumption is that there is a high correlation between entry-level workers and individuals holding entry-level jobs.

Given the interest in whether some workers are disadvantaged because of race, the paper also stratifies the data by race/ethnicity. Four racial/ethnic categories are used: non-Hispanic white (white), non-Hispanic black (black or African American), Hispanic (Latino), and other (primarily representing Asians and Pacific Islanders).

This paper will not use multivariate techniques. Therefore, it will not attempt to offer empirically derived explanations of causation. Instead, it describes the changes and offers some possible hypotheses.

Description of Occupation Groups

The paper used three broad occupation groups to analyze the employment prospects of non-college-educated workers. The occupation groups were from the 1990 Census of Population — Occupation, Classification Standard Occupation Codes (SOC).

Core Technology:

Engineers, architects, and surveyors — SOC: 43-63

Mathematical and computer scientists — SOC: 64-68

Other Technology Related:

Technical writers and designers — SOC: 184-185

Technicians and related occupations — SOC: 203-235

Computer equipment operators — SOC: 308-309

Financial records processing occupations — SOC: 325-336

Communications equipment operators — SOC: 348-353

Dispatchers — SOC: 359

Production coordinators — SOC: 363

Traffic, shipping, and receiving clerks — SOC: 364

Stock and inventory clerks — SOC: 365

Supervisors, mechanics and repairers — SOC: 503

Vehicle and mobile equipment mechanics and repairers — SOC: 505-517

Industrial machinery repairers — SOC: 518

Machinery maintenance occupations — SOC: 519

Electrical and electronic equipment repairers — SOC: 523-533

Electrical and electronic equipment repairers — SOC: 683

Basic Occupations are all other occupations that are not in the core technology or the other technology group.

APPENDIX B: TABLE AND FIGURES

TABLE B-1. CHANGES IN PERCENT OF TOTAL FULL-TIME EMPLOYMENT HELD BY ENTRY-LEVEL WORKERS

OCCUPATION	1992 PERCENT OF EMPLOYMENT	1992-1999 ANNUAL CHANGE	1994-1999 ANNUAL CHANGE
BASIC	9.6%	2.5%	2.1%
CORE TECHNOLOGY	3.6%	5.3%	9.5%
OTHER TECHNOLOGY	7.2%	1.8%	3.0%
ALL WORKERS	9.1%	2.5%	2.3%

Figure B-1. Relative Wages by Occupation for All Workers 18-64 Years Old

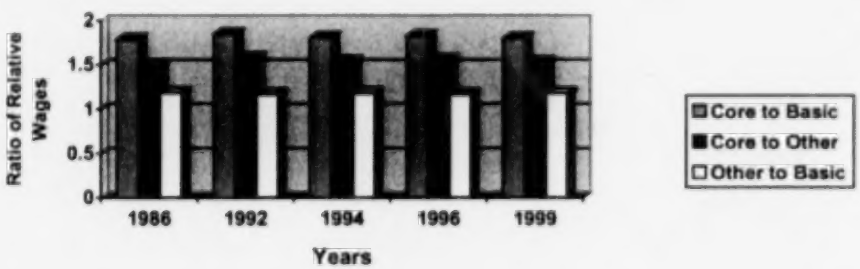

Figure B-2. Relative Wages by Occupation for Entry-Level Workers